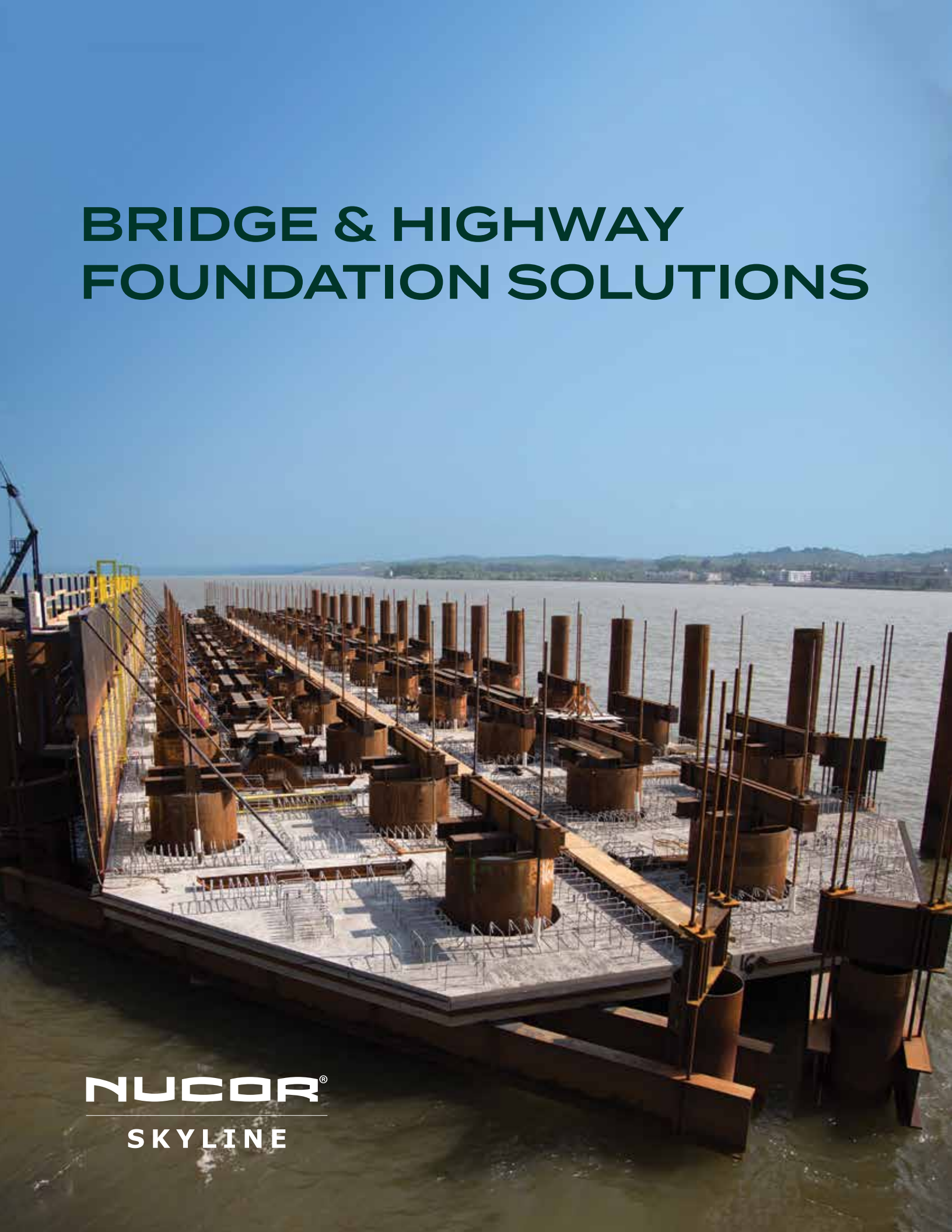
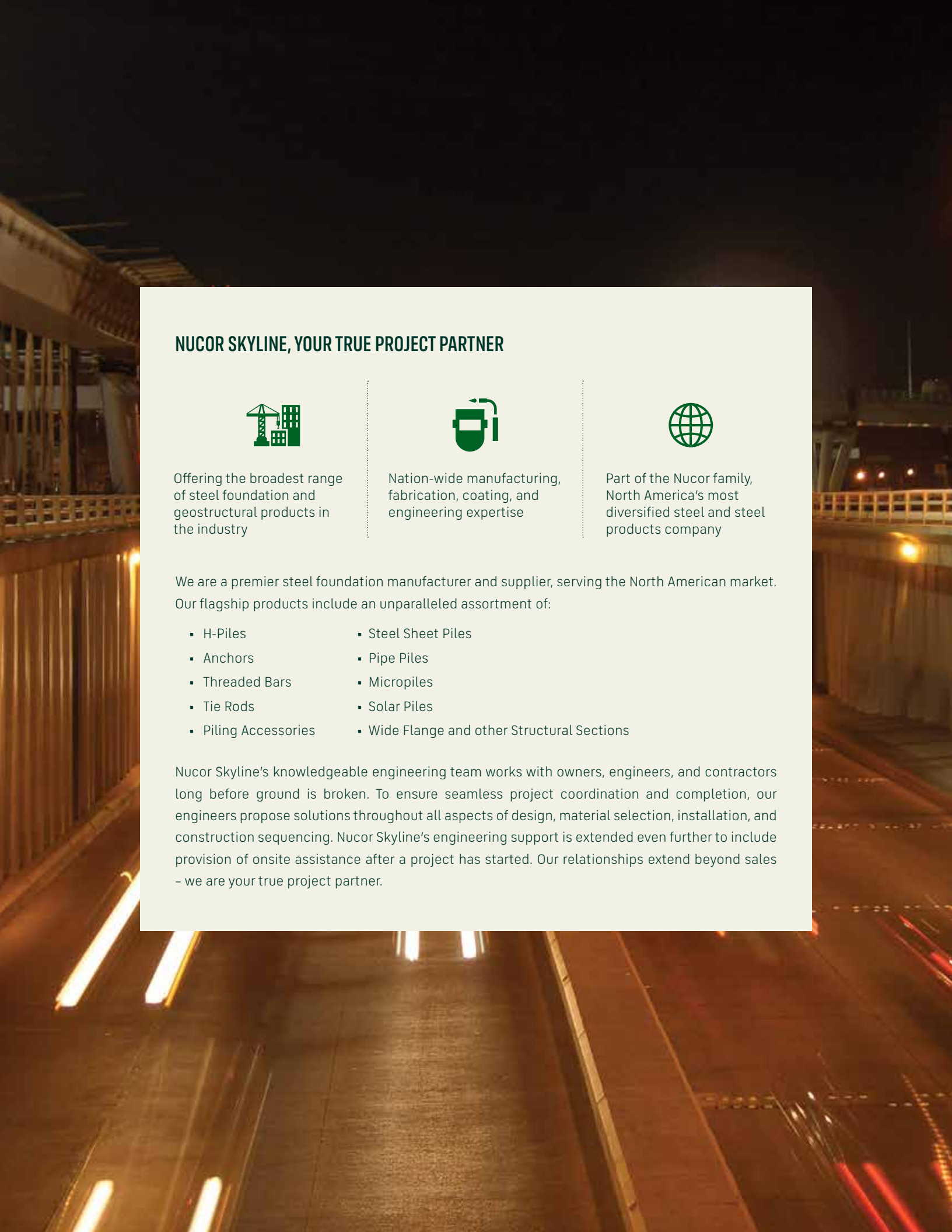
BRIDGE & HIGHWAY FOUNDATION SOLUTIONS



NUCOR®

SKYLINE



NUCOR SKYLINE, YOUR TRUE PROJECT PARTNER

Offering the broadest range of steel foundation and geostructural products in the industry

Nation-wide manufacturing, fabrication, coating, and engineering expertise

Part of the Nucor family, North America's most diversified steel and steel products company

We are a premier steel foundation manufacturer and supplier, serving the North American market. Our flagship products include an unparalleled assortment of:

- H-Piles
- Anchors
- Threaded Bars
- Tie Rods
- Piling Accessories
- Steel Sheet Piles
- Pipe Piles
- Micropiles
- Solar Piles
- Wide Flange and other Structural Sections

Nucor Skyline's knowledgeable engineering team works with owners, engineers, and contractors long before ground is broken. To ensure seamless project coordination and completion, our engineers propose solutions throughout all aspects of design, material selection, installation, and construction sequencing. Nucor Skyline's engineering support is extended even further to include provision of onsite assistance after a project has started. Our relationships extend beyond sales – we are your true project partner.

BRIDGE & HIGHWAY FOUNDATION SOLUTIONS FROM NUCOR SKYLINE

There are few companies that are as deeply involved in bridge foundations and retaining walls in North America as Nucor Skyline. From 20 foot wide county road bridges to multi-billion dollar iconic structures, all of Skyline's products are used in highway construction.

There are many applications for Nucor Skyline products in bridge and highway construction:

- Bearing piles
- Bridges
- Gantry signs
- Temporary and permanent retaining walls
- Sight and sound walls
- Anchors for slope stabilization

Nucor Skyline provides many different types of bearing piles:

- Driven Piles
  - H-pile
  - Pipe piles
  - Sheet pile
- Drilled Piles
  - Drilled shaft casing and threaded bar cages
  - Auger cast reinforcement
  - Micropile casing
  - Hollow bars

Nucor Skyline also offers points, driving shoes and splicers for various types of piles.

Bridge construction often involves temporary retaining structures in addition to the permanent walls. All of these products may be used for either phase of construction.

- Sheet piles, combined wall systems: Used for cofferdams, bridge abutments, wing walls and road widening.
- H-piles, wide flange beams: Used in beam and lagging walls, secant pile walls, sound walls and bracing for cofferdams.
- Threaded bar, strands, hollow bar: Used as anchors for any of the above walls and for slope stabilization.

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BEARING PILES

DRIVEN PILES

Driven steel piles are the most reliable type of foundation due to their rigorous testing. In addition to structural testing of the steel pile itself, the capacity of the soil that supports the pile is also tested during the installation process. A combination of the installation method and the test results provides the engineer with powerful and accurate information on the capacity of the driven piles.

When a driven pile is installed, it is subjected to loads which are higher than the pile is likely to experience during service and it carries those loads hundreds of times in quick succession. As a pile begins to reach capacity, the installation rate slows down and blows from the hammer rise to about 120 blows/foot. At this point, the pile is carrying loads very similar to the design loads. The installation rate of the pile and the blow counts are recorded in the driving record. No other foundation element sees service level loads hundreds of times during installation and this, along with testing, allows the engineer to save as much money as possible for the owner through optimization of the pile design.

Most driven pile projects have a small percentage of the piles that are either statically or dynamically tested, called test piles. Test piles are used to determine the required length of all other piles, called production piles. Once those piles have been tested, their driving records can be compared to the driving records of all the other piles. If the driving record of a production pile does not meet that of a test pile, additional length may be spliced onto the piles and driven further into the ground to achieve the required load capacity.

H-piles, pipe piles and sheet piles are capable of carrying significant loads. Nothing is more efficient than an HP when rock or a hard bearing layer is within easy driving distance. For a good combination of skin friction and end bearing, or when vertical or lateral loads are very high, pipe piles are the best choice. Sheet piles are particularly useful in applications where they can simultaneously be used as both a retaining wall and a bearing pile.

Sheet piles carry full load of bridge in Paramus, NJ.

24″ x 0.500″ spiralweld pipe piles.

18 #18 grade 75 threaded bars for 72″ drilled shaft in Minnesota

DRILLED PILES

Drilled piles for bridge construction are mostly drilled shafts and micropiles. Nucor Skyline supplies small diameter threaded casing for micropiles, large casing for drilled shafts and threaded bars for reinforcement. The drilled hole for the shaft is kept open with slurry, temporary casing or permanent casing.

Drilled Shafts

- Typically larger than 18″
- Utilizes a threaded bar or rebar cage for reinforcement
- Hole is kept open with a slurry or casing installed in segments
- Casing is installed as single pieces
- Does not necessarily reach a deep hard layer

Micropiles

- Typically less than 14″ in diameter
- Utilizes permanent casing and a single threaded bar for reinforcement
- Grout is installed under pressure
- Almost always drilled into a bearing layer
- Casing is threaded and installed in short lengths

There are several good reasons to use permanent casing for drilled shafts. First, and most important, is that the casing can be used to keep the drilled hole for the shaft open so that the bottom can be inspected and thoroughly cleaned. If slurry is used, it is much more difficult to prevent soft bottom problems. Casing also prevents the soil from pushing into the shaft. This can weaken the concrete mix or create voids in the shaft. In addition to the loss of compressive strength,

Installation of casing for drilled shaft.

Cleaning out drilled shaft casing in St. Louis, MO.

Threaded bar cages for drilled shafts in New York

DRILLED PILES (CONT'D)

the concrete voids can also lead to reduced concrete cover of the cages. The casing allows for much more reliable placement of the cage and flow of the concrete.

Steel pipe has significant bending and vertical load carrying capacity. As the drilled shaft sheds load through skin friction, the size of the cage can be reduced. Nucor Skyline threaded bar cages make it easy to vary the number, position and sizes of bars at varying elevations.

An often overlooked benefit of the casing is that it performs one of the two functions of the spiral reinforcement. For traditional cages, the spiral prevents the concrete from blowing out the side of the shaft. Pipe works very well at containing the concrete and even very thin-walled casing can take the place of a robust spiral.

The other function of the spiral reinforcement to ensure alignment of the vertical bars during construction. Nucor Skyline threaded bar cages use ring plates, typically spaced 10-15 feet apart, to ensure alignment of the threaded bars. Eliminating the spiral reduces the cost of the cage itself and allows for better concrete flow through the shaft, reducing the potential for concrete voids. This extra space also allows for concrete mix designs with lower slump values and higher strengths, which can reduce the overall size and cost of the drilled shaft.

High strength threaded bar cages offered by Nucor Skyline make construction of deep shafts very quick, easy and reliable:

- Versatile due to the variety of bar sizes, grades and threaded connections
- Ring plates and fully threaded connections allow the designer to optimize the cage design by placing different sizes and numbers of bars at different elevations
- Couplers are capable of taking the full tensile capacity of the bar so it is not necessary to overlap bars
- Very long cages can be made in the shop, disassembled into partial lengths (60′ or less) and then reassembled on site with tap through couplers

Pumping concrete for drilled shafts in Puerto Rico.

Reinforcement cage made with spiralweld pipe. Additional threaded bars installed inside pipe.

WALLS

RETAINING WALLS

In highway construction, retaining walls are used for a variety of reasons:

- Sheet pile bridge abutments and their wing walls are used to control the slope adjacent to the road and protect the abutment from scour
- Used to widen roadways in both cut and fill situations
- Used to support the fill underneath the roads approaching overpasses

Different types of retaining walls and soil conditions require different solutions.

Sheet piles can carry significant vertical loads and are a very versatile product for both temporary and permanent retaining walls. One of their biggest advantages is the speed at which they can be installed. The vertical load capacity of a sheet pile would be similar to that of an h-pile or pipe; there is no difference in the stress calculation. Sheet piles are typically subject to significant bending loads, so in the case where a vertical load is applied to the sheets as well, it is recommended that the designer check the combined stresses.

If the stresses or deflections are too high, sheet piles can be anchored with tie rods or grouted anchors. In temporary cofferdams, the sheet piles can be internally braced. Properly designed and protected steel sheet piles can achieve design lives of 75+ years. Pre-drilling can help facilitate the installation where driving conditions are especially hard.

Beam and lagging walls are an excellent choice in hard driving conditions. H-piles can be driven into very hard soils or dropped into holes predrilled into bedrock. Spacing the piles further apart reduces the amount of required drilling, but increases the required beam size. Beam and lagging walls are one of the most economical types of temporary retaining walls and can be built with h-piles or other beams. Like sheet piles, they can be anchored, but only the beams need to be anchored so a waler is not always required. For permanent walls, concrete panels can be used in place of the wooden lagging.

Soil nail walls are built with threaded bar and work very well in cut situations. A hole is drilled into the slope and the threaded bars are installed then grouted, interrupting the failure plane of the soil. Soil nail walls are built as the ground is excavated so the soil needs to have apparent cohesion. These types of walls can be especially useful for road cuts in hilly terrain.

Wide flange beams can also be used in secant pile walls. Secant pile walls are overlapping drilled concrete piles with a beam placed in every other hole for added strength. Secant pile walls are desirable in locations where low noise and low vibration is required given that the piles are drilled, and not driven. Secant pile walls cannot be used on a wall that requires backfill, but they are sufficient in almost every other situation. As with other wall systems, grouted anchors can be used to support secant pile walls.

Sound walls with steel beam posts in Virginia.

SOUND WALLS

Sight and sound walls are different from retaining walls in that their primary purpose is non-structural. Beams and pipe piles can be used as the foundation under the posts, and the beams can be utilized as the posts themselves. Although most sound walls do not carry any significant loads, some may be used in conjunction with retaining walls. Sound wall construction almost always coincides with cutting and/or filling for road widening.

New lanes often need structural retaining walls at the same location as the sight and sound walls. For efficient construction, steel piles can be used as the bending element in the retaining wall and the post for the sound wall.

Sight walls are often used to screen residential areas from highways, but they can also be used on the highways themselves. Walls, strategically placed at different locations on over passes, can reduce road glare significantly.

SLOPE STABILIZATION

Stabilizing slopes next to highways is a big problem in certain environments and soil conditions. It is not always practical, or feasible, to contain these slopes with retaining walls and therefore the slope has to be reinforced. Grouted anchors can be effective at stabilizing slip planes or securing rock faces. Anchors can also be used to secure precast concrete panels or other structural components to the slope to prevent erosion or rock falls. The equipment used to install anchors is relatively small and it can access areas that large earth moving and pile driving equipment cannot.

High strength, 150 ksi tensile, threaded bar works well for grouted anchors. For long anchors, strand systems tend to be more efficient. Nucor Skyline has a full line of hot and cold rolled threaded bars and the most advanced strand system in the world.

Slope stabilization with grouted soil anchors.

Slope stabilization with grouted soil anchors.

THE STEEL SHEET PILE ADVANTAGE

Bridges are an integral part of our transportation network. Building and repairing bridges quickly is vital for maintaining an effective and smooth running highway and transportation system. Steel sheet piles offer an accelerated bridge construction method that minimizes the impact to the flow of people and goods across the network.

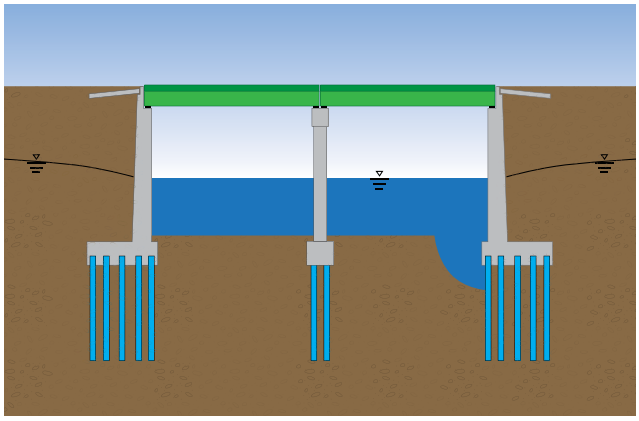
BRIDGE ABUTMENTS

Using steel sheet piles when building bridges offers the following advantages:

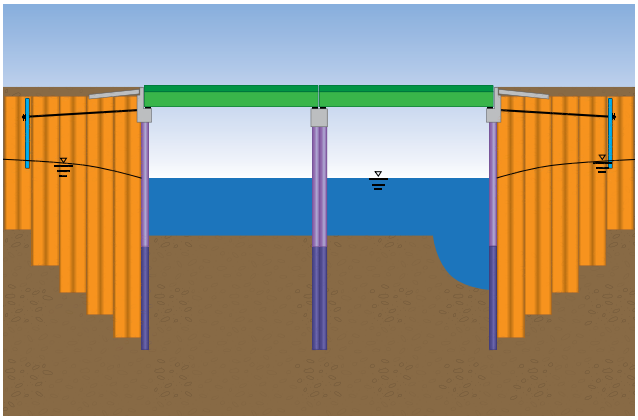
- Allows for placement of abutments within close proximity to each other to reduce span
- Speed of construction in bridge abutments and wing walls
- Preventing scour as 57% of bridge failures is due to scour

Bridge abutments have two primary functions in bridge construction. One is to support the vertical loads of the bridge and the other is to act as a retaining wall for the soil that supports the roadway. Wing walls support the soil adjacent to the abutments.

Most bridge spans are dictated by the terrain or the road or stream they are crossing. When crossing streams and other water ways, it is usually easier to build the abutment away from the water so the contractor does not have to build temporary cofferdams. Building the abutments away from the water increases the bridge span which increases the cost of the bridge. As spans increase, the moments increase as a function of the length squared and the deflections increase as a function of length to the fourth power. If a bridge span is increased by 10%, the moment increases by 21% and the required stiffness increases by 46%. Using sheet piles to carry the vertical loads from the bridge and the lateral loads from the soil ensures the span is as short as possible and speeds up construction time. Steel sheet piles can carry significant vertical loads just like any other steel pile. Individual sheet piles have been load tested to well over 100 tons (~50 tons/ft of wall). This is more than enough capacity for most bridges. Since most bridges are quite short, the steel sheet piles have plenty of strength left over to handle the bending loads from the soil, and bridge moments in the case of integral abutments.



Piers/Bridge Abutments without sheet piling: Scour exposes piles and decreases passive pressure in front of abutment.



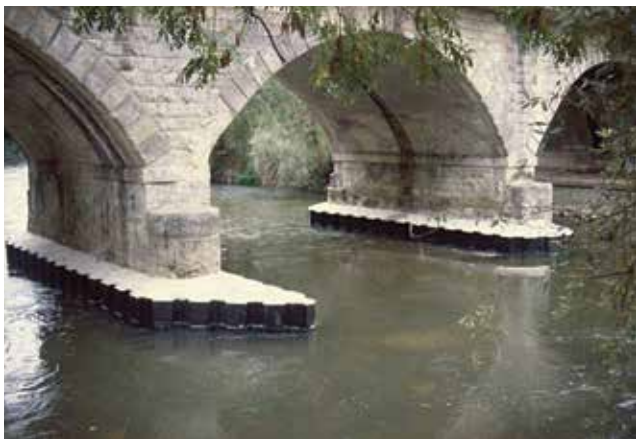
Piers/Bridge Abutments with sheet piling: Sheet piles protect the bridge from scour related problems.

Permanent steel sheet piles used for scour and impact protection

BRIDGE PIERS

Bridge piers are are used when the bridges are too long to be carried on a single span or when it is cheaper to add a pier than to increase the strength and stiffness of the span. Most bridge piers are built by using a temporary cofferdam to gain access to the riverbed. Bearing piles are installed and the bridge pier is built on top of those bearing piles. The cofferdam is then flooded and removed. On navigable rivers, a fender system is often installed around the pier. More than half of all bridge failures in the US are due to water problems and taken with the second leading cause of failure, impact, make up 69% of all bridge failures.

Using permanent sheet pile cofferdams can speed up construction and protect the pier from impact and scour. The size of the sheet piling and bracing system in a temporary cofferdam is determined primarily by the depth of the water. If the cofferdam is left full of water, the pressure on the sheet piles is almost nothing and any bracing system can be removed. Bearing piles can be driven under water to the same elevation they would have been driven to in a dewatered cofferdam. Once the piles are in place, the concrete pier can be poured using the sheet piles as formwork. Placed from the bottom up, the concrete displaces the water as it rises. The permanent sheet piling is left in place for scour protection and to protect the pier from impact. The construction would be very fast and the cost difference would be minimal. Risk reduction for bridges should be focused on the pier since that is where failure is most likely to occur.



Permanent steel sheet pile cofferdam used as form work, and scour and impact protection.

Permanent steel sheet pile grid utilized to take vertical load of Lincoln Street Bridge and Dam in Wichita, Kansas.

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